few basic steps. First, groups such as the NASA Goddard Community Coordinated Modeling Center (CCMC) will select models from the community for basic validation and verification. On the basis of these evaluations, DTC will rigorously test select models to detect any faults in codes and evaluate accuracy rates at different scales and parameter extremes.

But the main work will be in creating operational outputs (see Figure 1). "This means stating all predictions in a statistical sense—like 'there is a 40% chance of rain in Cleveland tomorrow morning, heavy at times,' but with a space weather slant," explained SWPC's Victor Pizzo, a physicist working on DTC.

The example of terrestrial weather forecasting will heavily guide DTC. "When the first numerical models were used in terrestrial meteorology, the forecasts actually did worse than those created manually by people using charts," Bogdan said. "We'll probably run into that, but we'll push forward. Right now, we can only anticipate geomagnetic storms about 30 to 40 minutes in advance. We'd like to see that go up to 2 to 3 days."

Given that SWPC is a critical system for national security interests, the level of information technology and security can make it difficult for SWPC to interact freely with the community. Operationally, DTC fills a need within the space weather community because it will be set up to allow discourse among the government, the academic community, and the private sector. This is particularly important because SWPC's "consumer base is very broad and diverse, with needs for output quite unlike what most researchers might be familiar with," Pizzo explained.

With support from AFWA now and from NOAA starting in fiscal year 2010, DTC will be the first governmental venture into sustained efforts to bring space weather research models into operational capacity. Within the structure of DTC, "we will never be done with a model," Bogdan said. "After a model comes to us, we may use it and then discover that it does not perform as well as we hoped. Models can overestimate, underestimate, give false alarms. We will take those experiences, go back to the research community, and ask them if they can figure out why."

SWPC has been seeking partnerships with organizations familiar with the complex task of transitioning large research-grade models to operational status. To that end, DTC will not be accepting just any space weather model—it will wait to bring in models that will substantially increase monitoring capability. "We're looking for models that are not just 2–3% above current forecasting efficiency," Bogdan explained. "Models that we accept must pass a certain threshold so that they are meaningful to customers. This may mean that the absolute best science code with the most complicated and detailed physics may not be the one that we actually use."

To help with model selection, the National Center for Atmospheric Research (NCAR) Research Applications Laboratory and High Altitude Observatory have been commissioned, with interim funding provided by AFWA, to draft a proposed DTC structure and suggest a test and evaluation process for introducing models into DTC.

For more information on the proposed DTC, contact Victor Pizzo at vic.pizzo@noaa.gov.

***Mohi Kumar** is a staff writer for the American Geophysical Union.*

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Funding to Boost the Commercialization of Space Weather Products

Space weather research at Utah State University (USU), in Logan, has been awarded a grant from the state of Utah to help transition models originally developed for the U.S. Department of Defense into commercially viable products.

The grant, awarded by the Utah Science Technology and Research Initiative (USTAR), will distribute US$4 million over 5 years to the USU team working on a research effort called Global Assimilation of Ionospheric Measurements (GAIM). GAIM creates specifications and forecasts for global, regional, and local distributions of upper atmospheric and ionospheric densities, temperatures, and winds. It is the operational space weather model for the U.S. Air Force Weather Agency and is used in studies at air force and naval research laboratories.

"The U.S. military relies on space weather warnings to protect satellites and ground-based systems that support our armed forces," explained Robert Schunk, a physics professor at USU and the principle investigator for GAIM. "System failures can cost lives and threaten national security."

As society becomes more dependent on sophisticated spaceborne and ground-based technological systems, space weather forecasting is becoming increasingly crucial to a functioning economy. "Ionospheric turbulence, similar to hurricanes and tornadoes, interferes with daily life and the operations of businesses," Schunk said. "Economists estimate that space weather costs the global economy from $200 to $400 million each year."

Blasts of solar wind can generate convective ionospheric storms, which disrupt over-the-horizon-radars, air traffic control systems, and meteorological forecasting. Surges in radiation levels can disrupt global positioning, navigation, and communications systems, hindering everything from cell phone usage and planning flight routes to surveying technologies and sea-based oil drilling. Geomagnetically induced currents can hasten the corrosion of pipes and short out power grids, leaving whole communities without electricity.

"Between the aviation, telecommunications, and utility markets, we think there is a billion-dollar potential in expanding GAIM to the civilian community," said Michael O'Malley, a representative from USTAR.

A particular focus will be on boosting services to the aviation industry. "There are about 6000 planes flying over the United States on any given morning," Schunk said. "Better geolocation would allow planes to be flown closer together, which would help reduce delays at airports." Further, coordination through GAIM could help the U.S. Federal Aviation Administration (FAA) to provide better spatial resolution on ionospheric parameters used in the FAA's Wide Area Augmentation System, an air navigation aid. "Certain outputs of GAIM could also help other countries establish better air traffic control systems," Schunk added.

As society becomes more dependent on sophisticated technological systems, space weather forecasting is becoming increasingly crucial to a functioning economy.

GAIM also has applications for humanitarian efforts, particularly in the realm of disaster relief. For example, a large solar flare in September 2007 cut off high-frequency communications, leaving U.S. disaster relief workers without a communications system after Hurricane Katrina. "GAIM products would include maps of what frequencies—if any—can be used for communication," Schunk said.

USTAR's mission is to foster technological and economic development in Utah while attracting new talent to the state. "USU has long been an expert in space and aeronautics research, which is one reason the USTAR governing board looked favorably on its application," O'Malley said.

The new funding for GAIM, which began in December 2008, will be used to create the International Center for Space Weather Forecasting, to be housed in USU's Center for Atmospheric and Space Sciences. GAIM's research group currently is composed of eight people, and Schunk anticipates that the center will hire 12–15 additional staff, including three senior scientists and several postdoctorate researchers and graduate students, to work with USU researchers to develop continuous forecasts and even specifically tailored applications for clients in various industries.

"Ultimately, we'd like to generate a spin-off company focused on commercial space weather products," Schunk said.

Mohi Kumar *is a staff writer for the American Geophysical Union.*

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